AIUM Practice Parameter for the Performance of Duplex Sonography of Native Renal Vessels

The American Institute of Ultrasound in Medicine (AIUM) is a multidisciplinary association dedicated to advancing the safe and effective use of ultrasound in medicine through professional and public education, research, development of clinical practice parameters, and accreditation of practices performing ultrasound examinations.

The AIUM Practice Parameter for the Performance of Duplex Sonography of Native Renal Vessels was revised by the American Institute of Ultrasound in Medicine (AIUM) in collaboration with other organizations whose members use ultrasound for performing this examination(s) (see "Acknowledgments"). Recommendations for personnel requirements, the request for the examination, documentation, quality assurance, and safety may vary among the organizations and may be addressed by each separately.

This Practice Parameter is intended to provide the medical ultrasound community with recommendations for the performance and recording of high-quality ultrasound examinations. The parameters reflect what the AIUM considers the appropriate criteria for this type of ultrasound examination but is not intended to establish a legal standard of care. Examinations performed in this specialty area are expected to follow the Parameter with recognition that deviations may occur depending on the clinical situation.

Indications

Indications for renal duplex sonography include, but are not limited to:

1. Evaluation of patients with hypertension when there is a strong suspicion of renovascular hypertension (for example, uncontrolled hypertension despite optimal medical therapy, hypertension with progressive decline in renal function, progressive decline in renal function associated with angiotensin-converting enzyme inhibition therapy, abrupt onset of hypertension).[1,2]
2. Follow-up of patients with known renovascular disease who have undergone renal artery stent placement, angioplasty, or surgical bypass, or who have a known unilateral stenosis with concern for a stenosis in the contralateral kidney.

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3. Evaluation of an abdominal or flank bruit.
4. Evaluation of a suspected vascular abnormality, such as an aneurysm, pseudoaneurysm, arteriovenous malformation, fistula, or following treatment of any of the above.
5. Evaluation of vascular causes of renal insufficiency, for example, renal resistance measurements for evaluation of acute kidney injury and chronic kidney disease.[3,4]
6. Evaluation of flow in patients with known aortic dissection, prior aortic intervention (including aortic stent grafts), trauma, other abnormalities or conditions that may compromise renal blood flow, and in patients with suspected renal parenchymal infarct.
7. Evaluation of discrepant renal size, defined as length discrepancy between the right and left kidney of >2 cm in adults.
8. Concern for aortic or renal artery thrombosis in infants who have or have had an aortic catheter, such as an umbilical arterial catheter.
9. Evaluation of unilateral hydronephrosis in children and adolescents.[5]
10. Evaluation for congenital or syndromic causes of renovascular hypertension.
11. Evaluation for renal vein stenosis or thrombosis.
12. Evaluation of renal tumor extension into the main renal vein and differentiation of bland from tumor renal vein thrombus.
13. Evaluation of the renal vein in patients with suspected Nutcracker syndrome (compression of the left renal vein as it traverses the space between the aorta and superior mesenteric artery).

There are no absolute contraindications to performing this examination.

Qualifications and Responsibilities of Personnel

Physicians interpreting or performing this type of ultrasound examination should meet the specified AIUM Training Guidelines[5] in accordance with AIUM accreditation policies.[6]

Sonographers performing the ultrasound examination should be appropriately credentialed[7] in the specialty area in accordance with AIUM accreditation policies.[6]

Physicians not personally performing the examination must provide supervision, as defined by the Centers for Medicare and Medicaid Services Code of Federal Regulations 42 CFR §410.32,[8] which is available from the U.S. Government Publishing Office.

Request for the Examination

The written or electronic request for an ultrasound examination must originate from a physician or other appropriately licensed health care provider or under the provider's direction. The clinical information provided should allow for the performance and interpretation of the appropriate ultrasound examination and should be consistent with relevant legal and local health care facility requirements.

Specification of the Examination

The written or electronic request for renal duplex sonography should provide sufficient information to demonstrate the medical necessity of the examination and allow for its proper performance and interpretation.

Documentation[9] that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). Additional information regarding the specific reason for the examination or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

The study is generally performed for both kidneys. If not, the report should state the reason for a unilateral study (eg, evaluation of unilateral renal stent, known solitary kidney, etc).

When possible, obtaining the following grayscale and color/spectral Doppler images is recommended:

Renal Arteries

The study consists of grayscale imaging of the kidneys and limited grayscale views of the aorta with color

and spectral Doppler of the intrarenal and extrarenal vessels and juxtarenal aorta.

1. Grayscale Imaging

The longest renal length should be measured and reported. In patients who have not had recent cross-sectional imaging of the kidneys, a complete renal ultrasound examination may be considered. See the AIUM Practice Parameter for the Performance of an Ultrasound Examination of the Abdomen and/or Retroperitoneum.[10] Longitudinal and transverse views of the aorta should be obtained at the level of the kidneys and above.

2. Color and Spectral Doppler Evaluation

Analysis of the main renal artery and intrarenal arterial waveforms should be performed to evaluate for renal artery stenosis.

Careful attention to technique is important to ensure accurate results. This may include selecting a transducer that is appropriate for the patient's body habitus, optimizing color Doppler parameters, using an appropriate spectral Doppler sample volume, optimizing the velocity scale for the size of the waveform to avoid color and spectral Doppler aliasing, and/or to improve evaluation of waveform morphology. This may require adjusting the scale (increasing or decreasing the baseline, pulse repetition frequency, and/or selecting a transducer with a different frequency). Angle correction is essential for determining blood flow velocity. Angle correction is typically made by placing the angle correction cursor parallel to the vessel walls. For renal evaluation, the angle between the direction of flowing blood and the ultrasound beam should be as small as feasible and should not exceed 60°.

a. Main renal artery and aorta evaluation

The entire main renal artery should be scanned along its long axis using optimized color Doppler parameters. Occasionally, power Doppler or grayscale imaging may be necessary to localize a portion of the artery. Inability to visualize a specific segment (eg, the origin) of the main renal artery should be reported.

Spectral Doppler waveforms should be obtained along the length of the main renal artery from the origin to the hilum at the lowest feasible angle of insonation.

At a minimum, the highest peak systolic velocities should be recorded at the origin/proximal, mid, and hilar segments of the main renal artery.[11–28] Peak systolic velocity should also be recorded at any site of color aliasing, narrowing, or suspected stenosis. If there is a significant stenosis, spectral Doppler waveforms should be recorded within the stenosis (to detect the high velocity jet flow) and distal to the stenosis (to detect post stenotic turbulence). In some patients, the distal disturbed waveform may be a sign of upstream stenosis. In young children/infants, one measurement of peak systolic velocity in the main renal artery is acceptable.[27]

An effort should also be made to search for accessory/duplicated renal arteries.[27,29,30] When visualized, peak systolic velocities should be recorded as described above.

An appropriate angle-corrected spectral Doppler waveform from the abdominal aorta at or slightly cephalad to the origins of the renal arteries should be recorded. Aortic peak systolic velocity at this level is used to calculate the renal aortic ratio or the ratio of the highest peak systolic velocity in the stenosed segment of the main renal artery compared with the peak systolic velocity in the aorta.

Renal artery stent evaluation should include (when possible) documenting peak systolic velocities in the proximal renal artery (if possible), within the stent, and distal to the stent.[31]

In infants with aortic thrombus after umbilical artery catheterization, the relationship of the thrombus to the right and left renal artery orifice and flow around the thrombus should be documented. If aortic thrombus is located near a renal artery orifice, waveforms should be obtained in the involved main and intraparenchymal renal arteries to assess renal perfusion.

b. Intrarenal arterial evaluation

Spectral Doppler waveforms should be recorded from segmental, interlobar, or arcuate arteries in the upper and lower poles and in the interpolar region (mid portion) of each kidney. It is important to use a fast sweep speed and optimize the velocity scale to ensure accurate and reproducible measurements. If acceleration index measurements are used in assessment, angle correction is

needed; the angle of insonation should be as low as possible, usually 30° or less.
Intrarenal waveform analysis consists of quantitative and/or qualitative evaluation of the arterial Doppler waveforms. Quantitative evaluation may include acceleration times, acceleration indices,[32,33] and/or resistive indices.[34–36] For qualitative analysis, the morphology of the waveform should be assessed, including the presence of a normal sharp systolic upstroke versus an abnormal tardus parvus waveform.[28,30,32,33] It may be necessary to document more than one spectral Doppler waveform in a specific region to ensure optimal interpretation. This is especially true in children in whom motion artifact can significantly degrade spectral and color Doppler image quality.

3. Contrast-enhanced ultrasound (CEUS)
The use of microbubble ultrasound contrast agents may be helpful in identification of the main renal arteries, in detection of duplicated or accessory renal arteries, in assessment of renal perfusion, and in more accurately depicting and localizing renal artery stenosis.[37] Note: This would be an off-label use of CEUS based upon current FDA approval status.

Renal Veins

1. For routine evaluation of the renal veins (ie, an examination not performed specifically for evaluation of suspected renal vein pathology), grayscale and color Doppler longitudinal views of the main renal veins with accompanying spectral Doppler waveform should be obtained.
2. If there is specific concern for renal vein stenosis or thrombosis, or if abnormal findings are present on routine examination, a more detailed protocol may be performed and may include the following:
   a. Grayscale Evaluation: The main renal vein should be imaged in longitudinal and transverse views. Note should be made of any area of suspected stenosis and/or intraluminal thrombus.
   b. Color and Spectral Doppler Evaluation: The main renal vein color and spectral Doppler waveforms and intrarenal venous spectral waveforms should be obtained to evaluate for renal vein abnormalities such as thrombosis or stenosis. In suspected stenosis or compression, velocity should be recorded proximal to, within, and distal to the affected segment. When renal vein thrombus is present on grayscale imaging, color, power, and/or spectral Doppler may be used to evaluate for vascularity within the thrombus, which would suggest tumor thrombus. The presence or absence of tumor or bland thrombus extending into the inferior vena cava should be documented.
   c. CEUS: The use of microbubble ultrasound contrast agents may be helpful in identification of main renal vein stenosis and/or thrombosis as well as tumor vascularity within thrombus. Note: This would be an off-label use of CEUS based upon current FDA approval status.

Documentation

Accurate and complete documentation is essential for high-quality patient care. Written reports and ultrasound images/video clips that contain diagnostic information should be obtained and archived, with recommendations for follow-up studies if clinically applicable, in accordance with the AIUM Practice Parameter for Documentation of an Ultrasound Examination.[9]

Adequate documentation is essential for high-quality patient care. There should be a permanent record of the ultrasound examination and its interpretation. Comparison with prior relevant imaging studies may prove helpful. Images of all appropriate areas, both normal and abnormal, should be recorded. Variations from normal size should generally be accompanied by measurements. Images should include the patient identification, facility identification, examination date, and image orientation. An official interpretation (final report) of the ultrasound examination should be included in the patient's medical record. Retention of the ultrasound examination images should be consistent both with clinical need and with relevant legal and local health care facility requirements.

Equipment Specification

Equipment performance monitoring should be in accordance with the AIUM Routine Quality Assurance of Clinical Ultrasound Equipment, Version 2.0.[38]

Duplex and color Doppler ultrasound of the renal arteries should be performed in real time using a scanner with color and spectral Doppler capabilities. Transducer selection should be based on body habitus. In adults, typically used transducer frequencies range from 2 to 9 MHz. In neonates, transducer frequencies of 7–15 MHz are typically used.

Quality and Safety

Policies and procedures related to quality assurance and improvement, safety, infection control, and equipment-performance monitoring should be developed and implemented in accordance with the AIUM Standards and Guidelines for the Accreditation of Ultrasound Practices.[6]

ALARA (As Low as Reasonably Achievable) Principle

The potential benefits and risks of each examination should be considered. The ALARA principle[39] should be observed for factors that affect the acoustical output and by considering transducer dwell time and total scanning time. Further details on ALARA may be found in the current version of the AIUM publication *Medical Ultrasound Safety*.[40]

Infection Control

Transducer preparation, cleaning, and disinfection should follow manufacturer recommendations and be consistent with the AIUM's Guidelines for Cleaning and Preparing External- and Internal-Use Ultrasound Transducers Between Patients, Safe Handling, and Use of Ultrasound Coupling Gel.[41]

Equipment Performance Monitoring

Monitoring protocols for equipment performance should be developed and implemented in accordance with the AIUM Standards and Guidelines for the Accreditation of Ultrasound Practice.[6]

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